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The World Wide Web Amateur Satellite Ground Station

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Introduction

The *World Wide Web Amateur Satellite Ground Station* (<http://gndstn.sp.nps.navy.mil>) (Figure 1) provides a glimpse into the world of digital communications Amateur Satellites through the Internet's World Wide Web. The *Web* is the fastest growing facet of the Internet today. It is characterized by its intuitive and easy to use graphical user interface client program, sometimes called a *browser* or *navigator*, which is available for a variety of computing platforms. The World Wide Web was conceived at the European Particle Physics Laboratory, CERN, in Geneva, Switzerland. The *Web's* designers sought to combine information from related projects through hypertext [1]. Eventually, the University of Illinois' National Center for Supercomputer Applications (NCSA) took the idea one step further and created the popular *NCSA Mosaic* browser program [2]. Since the introduction of the World Wide Web in 1990, its popularity has surpassed everyone's expectations. Prospective users can access the World Wide Web from work and school and through major information providers such as CompuServe or America Online as well as many local Internet Access Providers.

The *Web Ground Station* is located at the Naval Postgraduate School in Monterey, CA. It is part of the Satellite Development Program in the Space Systems Academic Group. The *Web Ground Station* is an outgrowth of the Amateur Satellite ground station that is provided for students to learn about the operation of low earth orbit digital communications satellites. The *Web Ground Station* is an experiment in combining two dissimilar networks via a gateway computer.

The Amateur Satellite Ground Station

The *World Wide Web Amateur Satellite Ground Station* starts with an Amateur Satellite ground station. At the center is an ICOM IC-970H dual band, multimode UHF/VHF transceiver. The antenna system is the Cushcraft AOP-1, Yaesu G-5400B azimuth/elevation rotors, and an ICOM AG-45 low noise preamplifier for the downlink. The terminal node controller (TNC) is an Advanced Electronics Applications, Inc. DSP-2232.

The computer is a 486DX-33 MHz with 8 Megabytes of RAM and 240 Megabyte hard drive. A L. L. Grace Kansas City Tracker/Tuner (KCT/T) card is plugged into an expansion slot. The KCT/T provides the interface between computer and the antenna rotor controller (for tracking) and transceiver (for tuning). An Ethernet Network Interface Card (NIC) is plugged into another expansion slot and provides the ground station's interface to the campus network and Internet. Figure 2 shows a system block diagram of the equipment for the *Web Ground Station*.

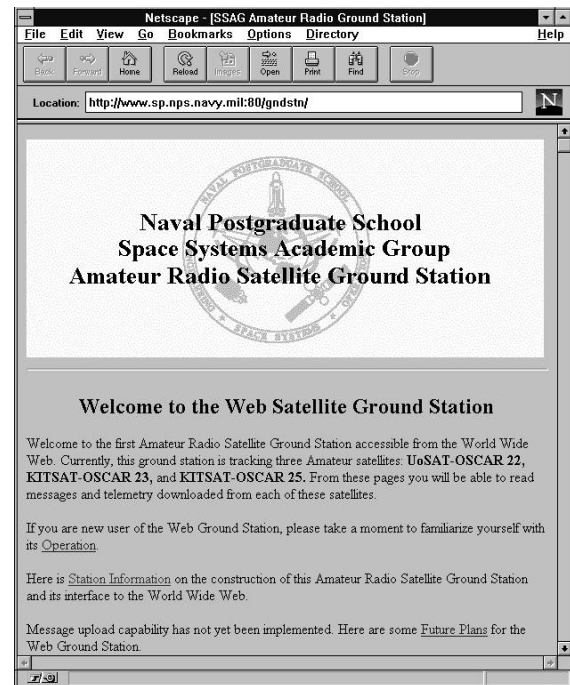


Figure 1. The Home Page of the WWW Amateur Satellite Ground Station

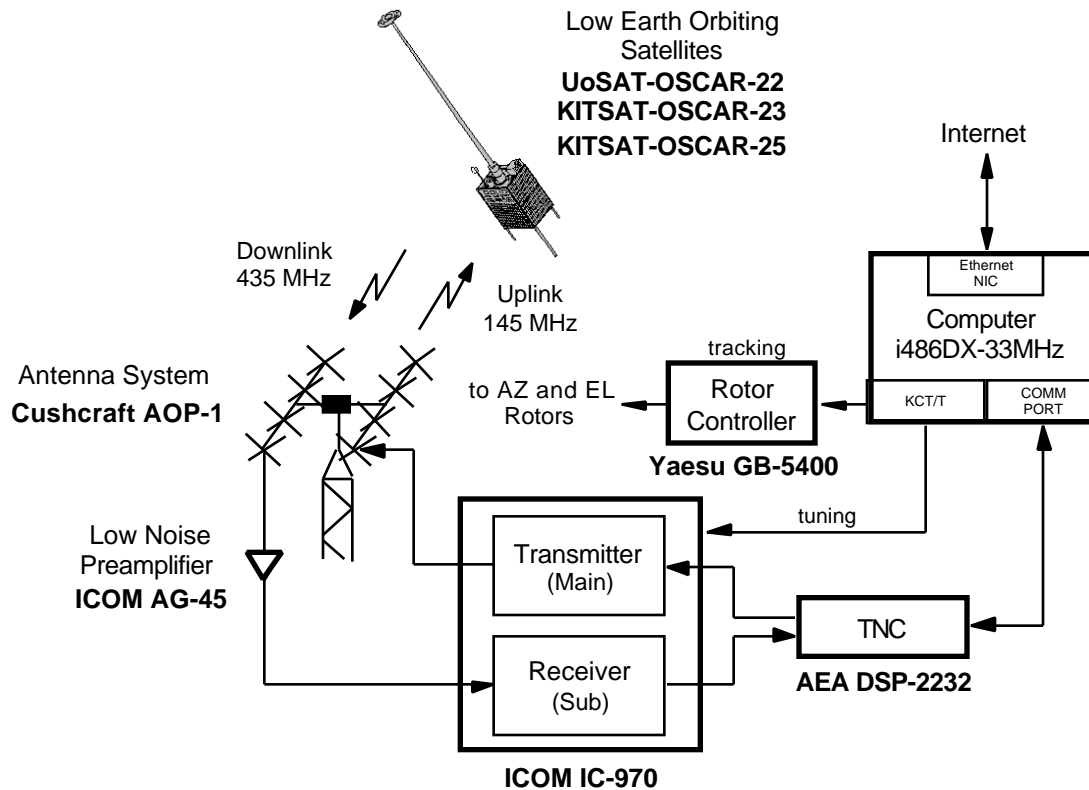


Figure 2. System Block Diagram of the Web Ground Station

Various softwares are loaded on the computer. The operating system is Microsoft Windows for Workgroups Version 3.11 with 32-bit extensions (Win32s) and TCP/IP protocol stack (Wolverine)¹. Controlling the satellite tracking and upload/download functions is Chris Jackson's, G7UPN/ZL2TPO, Windows Satellite Program (WiSP)² and David Hoatson's, KC6WYG, KCT/T Windows driver program. WiSP is an integrated suite of seven programs that schedules, tracks, tunes, composes and views messages, and transfers files to and from the satellites. The KCT/T driver program interfaces WiSP with the KCT/T card.

The World Wide Web server program is Windows httpd V1.4c written by Robert Denny³. The program runs under Windows 3.1 or Windows for Workgroups 3.11 and serves requests by the browser program for pages on the *Web Ground Station*. This combination of equipment and software creates an Amateur Satellite ground station that can track multiple satellites, unattended, 24 hours a day and serve documents to the World Wide Web.

Packet Satellites (PACSATs)

The *World Wide Web Amateur Satellite Ground Station* tracks and exchanges files with three amateur low earth orbit, digital communications, store-and-forward satellites: UoSAT-OSCAR-22, KITSAT-OSCAR-23, and KITSAT-OSCAR-25. These satellites communicate via 9600 bps FSK full duplex up and downlinks using the PACSAT Protocol Suite [3]. To better understand the inner workings of the *Web Ground Station*, a little background on how these digital communications satellites work is in order.

¹ Win32s and Wolverine are available from Microsoft's anonymous ftp site ftp.microsoft.com.

² WiSP is available from AMSAT NA, 850 Sligo Avenue, Silver Spring, MD 20910-4703; Phone: (301) 589-6062.

³ For more information about Windows httpd V1.4c see <http://www.city.net/win-httpd/>.

Messages uploaded to the satellites are prepared by the ground station software. The body of the message can be either text or binary information. The body is appended to a header which contains such information as the callsigns of the originating and receiving stations, title of the message, date and time of upload, and keywords. There are 28 possible fields in the header, divided into mandatory, extended, and optional categories [4] (Figure 3). When messages are uploaded to the satellite, the header information is removed and stored in the satellite's directory. The body of the message is assigned a sequential hexadecimal file number and stored in the satellite's memory.

The satellites transmit their directory listings separately from messages and files. This method facilitates a large number of ground based users each contending for resources on the satellite. Ground stations receive directory information from the satellite and scan it for messages that meet download criteria. If any messages are addressed to the callsign of the station or to ALL, the ground station transmits to the satellite and signals it to transmit the message.

Since the directory is transmitted separately from messages and files, the ground station maintains a listing of all the messages that reside on the satellite. When a message is transmitted to the ground station, only the body of the message is sent and the identity of the message is only known by its hexadecimal file number. Therefore, the ground station computer only maintains those messages addressed to it, to ALL, or messages overheard when broadcast to another ground station within the footprint of the satellite. When using WiSP's Message View program to read messages, the directory files are used to associate header information with the body of the message.

When directory listings, messages, or telemetry are downloaded, WiSP places them in their respective directories on the ground station computer. Directory listings have the filename MSPExxxx.PFH. The prefix MSPE stands for the MicroSat Protocol Engine, the program responsible for decoding information to and from the satellites. The xxxx is a sequential number assigned by WiSP. The PFH extension identifies the file as written in the PACSAT File Header (PFH) format. WiSP stores messages downloaded from the satellites in their original form: text for messages and binary for files. Text messages are stored in the MSGS subdirectory with the hexadecimal file number and MSG extension. Binary files are stored in the BIN subdirectory. Telemetry is captured by WiSP and labeled with a time stamp in the form of YYMMDDHH and an extension of TLM. Figure 4 summarizes the information flow from the satellite to the ground station computer.

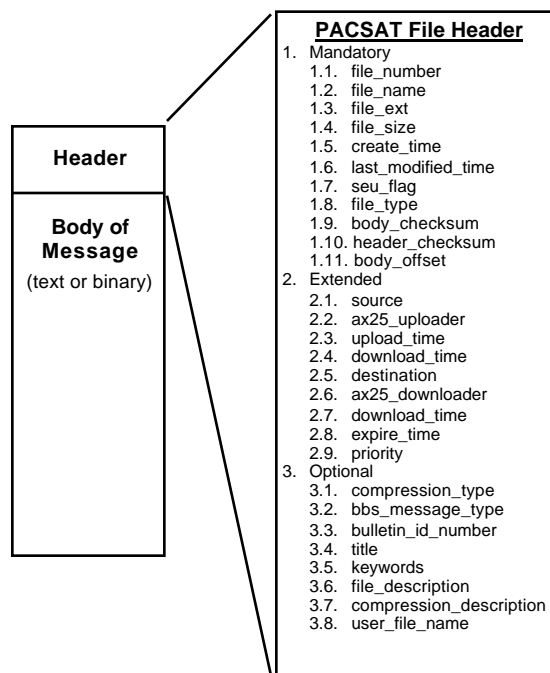


Figure 3. PACSAT messages are made up of the header and body

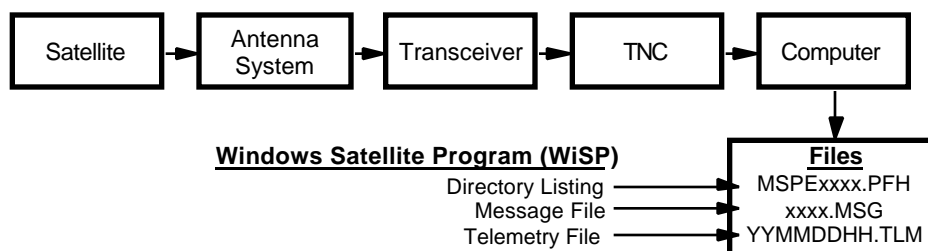


Figure 4. Information flow from the satellite to the ground station computer

The World Wide Web Interface

Once WiSP tracks the satellites and stores satellite directory information, messages, and telemetry on the ground station computer, the *Web* interface takes over. A few minutes after the satellite pass, WiSP schedules two custom programs to run. The first converts the directory listing into Hypertext Markup Language (HTML), the language of the World Wide Web, and the second decodes the captured telemetry and formats it into a text file.

The first custom program is called PFH2HTML.EXE. It reads the MSPExxxx.PFH file, parses it according to the PFH protocol, and writes a text file in HTML format. First the *Web* user clicks on the appropriate hypertext that requests the directory listing from the satellite of interest. From here the user can see a listing of all messages that are resident on the satellite. As mentioned before, not all messages are downloaded to the ground station. Therefore, when PFH2HTML parses the directory listing, it sees if the corresponding message is resident on the ground station computer. If it is, a hyperlink is made to the message. If the message is not resident, it is listed as normal text. Figure 5 shows a directory listing from KO-23. Hypertext is indicated by the underlined titles of the message. This indicates that the message is available to be read. By clicking on the associated hypertext the message is presented to the user. Hyperlinks allow the user to see at a glance which messages are available to read. This is an elegant interface and a fantastic demonstration of the power of hyperlinks. The interface is intuitive, easy to use, and does not distract the user.

The telemetry files are converted in the same fashion as the directory listings. The second custom program, called TLM.EXE, reads the raw telemetry and writes a text file. The user can choose to read the decoded telemetry or download the raw telemetry for later decoding with their own program.

The *Web Ground Station* tracks the satellites individually, downloads directory listings, messages, and telemetry, all while unattended. WiSP takes care of the tracking and placing of files into their appropriate directories and the custom programs PFH2HTML and TLM convert the files into HTML format for the *Web*. But the custom programs could not do their job if it were not for WiSP's unique feature of scheduling programs. PFH2HTML and TLM are scheduled to run 2 minutes after each satellite pass, so files are kept up to date. Anytime a user browses the *Web Ground Station* they are viewing the latest files available from the station's location. Figure 6 summarizes the flow of information between the files WiSP writes to the ground station computer and the custom programs that format them into their HTML counterparts for the *Web* server.

Title:	To:	From:	Date:	Time:
FELICIDADES	LU7DTK	LU1XCO	04-May-95	11:58
Thanks	N8AJD	KB1SF	04-May-95	12:09
<u>SatLink v.950419</u>	all	nz3f	04-May-95	12:11
<u>Re: KO-25 Passes</u>	VE3FRH	NSZEV	04-May-95	12:13
<u>Re: Dayton the aftermath</u>	KD7AI	KB2MVN	04-May-95	12:14
<u>Dayton</u>	KP4KEG	WA2N	04-May-95	12:17
Re: Windows 95	G4CSS	VE2OTT	04-May-95	12:19
Reqsat	FK8CR	VK2XGJ	04-May-95	13:21
KPC-9612	VE3BDR	W0TUP	04-May-95	14:08
Re: Thanks	KB1SF	N8AJD	04-May-95	14:09
Contest IARU	ALL EUROPE	IW0RFX	04-May-95	16:28
AK9S0504			04-May-95	17:00
EL9S0504			04-May-95	17:09
<u>Re: Windows95 Preview</u>	G7HCE	VE2OTT	04-May-95	16:07
Corta visita	EB2CJY	EA5XE	04-May-95	16:24
<u>Re:Professionale</u>	IV3GCV	IW0RFX	04-May-95	16:32
TP9S0504			04-May-95	17:00
EL9S0504			04-May-95	17:23
<u>Re:Dayton</u>	VE1HD	WA2N	04-May-95	12:17
EL9S0504			04-May-95	17:23
AL9S0504			04-May-95	17:59
AK9S0504			04-May-95	18:00
TP9S0504			04-May-95	18:01
TP9S0504			04-May-95	18:01
AL9S0504			04-May-95	18:04
gm	W7FEN	N7AUF	04-May-95	18:04

Figure 5. The KO-23 directory listing. Hypertext indicates messages that are available to read.

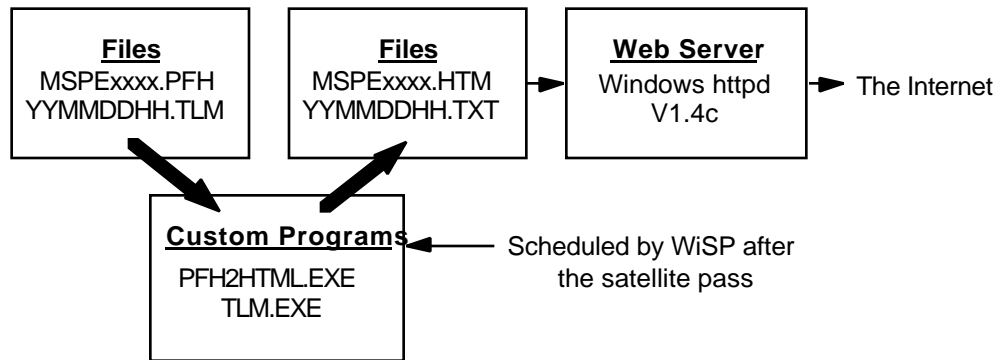


Figure 6. Web Server Information Flow

A Virtual Classroom

The previous sections describe the heart of the *World Wide Web Amateur Satellite Ground Station*, the ability to read directories, messages, and telemetry in near real time. The *Web Ground Station* also has pages that describe how to operate the *Web Ground Station* for first time user and hardware and software descriptions complete with graphics (Figure 7). There are also hyperlinks to other associated sites on the World Wide Web for those interested in exploring information provided by The Radio Amateur Satellite Corporation (AMSAT) and Tucson Amateur Packet Radio (TAPR) organizations.

Something Borrowed

PFH2HTML.EXE and TLM.EXE were written using a technique called “code reuse.” Source code was borrowed and modified from the microsat programs for the Linux operating system. John Melton, GØORX/N6LYT, the author, released the programs through the GNU General Public License⁴, making them freely available. It is John’s generosity that made the Web Ground Station possible. Thanks John!

Summary

Judging by the enthusiastic response and the many thousands of accesses, *The World Wide Web Amateur Satellite Ground Station* has been a resounding success. It has been accessed by Amateurs and non-Amateurs from all around the world. Even educators are finding the *Web Ground Station* useful for classroom demonstrations and it has given beginning satellite enthusiasts and seasoned Amateurs alike a glimpse into the world of Amateur digital communications satellites.

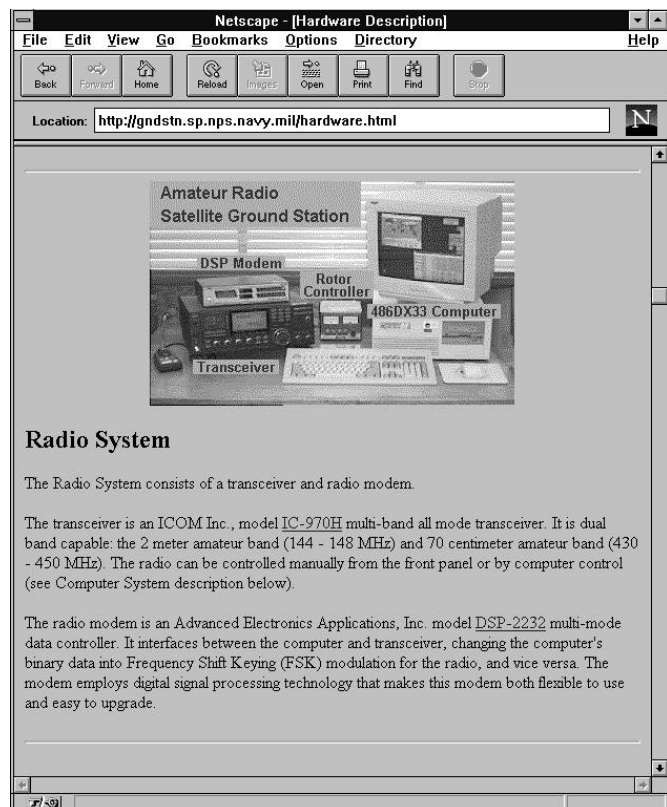


Figure 7. Hardware Description Page

⁴ “GNU General Public License, Version 2, June 1991,” Free Software Foundation, Inc. 625 Massachusetts Ave, Cambridge, MA 02139

Acknowledgments

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